Measurement of Seasonal Air Temperatures Near the Soil Surfaces¹

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Highlight

A study of the maximum air temperature near the soil surface at 11 grassland locations was made during the summer of 1968 using a simple maximum temperature indicator. Maximum temperatures within the first centimeter above the soil were found to exceed 144 F on a number of these locations. Although the range of indicators was not large enough to include the extremes at all locations, a seasonal pattern was identifiable. Large local differences in near-surface temperatures were frequently observed.

Presently, there is a lack of information describing the development and survival of forage plants in limiting environments. Temperature extremes are frequently recognized as an index for plant survival in these locations, but it is well known that many other factors (e.g., humidity, duration of exposure, plant age) influence the impact of temperature (Laude, 1964). It has been reported (Hallin, 1968; Gates et al., 1968) that maximum air temperatures near the soil surface in

FIG. 1. Variation in seasonal maximums in near surface temperature. Four of six sites at this sandstone location are shown.

the semiarid climate of the West exceed the values recognized as lethal for plants. Mutual shading or an insulating epidermis may serve to protect internal tissue on established plants during these times, but emerging seedlings or isolated individuals frequently succumb. Although temperature extremes are intuitively suspected as responsible for observed plant failures, effective remedial treatment to revegetate these harsh areas may require more knowledge of the present temperature regime. Measurements are often neglected due to instrumental difficulty, expense, and/or sampling problems. Few procedures provide any examination of the spatial variation in the temperature field. With a simple temperature indicator, we have been able to identify the limits and duration of extreme maximum temperatures on some of our poorly vegetated local areas.

Materials and Methods

The temperature indicator used consists of a small, U-shaped spring held in compression by a bead of temperature-sensitive wax (Fowler, 1970). If the wax is exposed to a temperature above the melting point, the spring is released. This indicator differs from

the wax pellets frequently used to indicate surface temperature in the size of bead, uniformity of radiation absorption, and ease of reading.

Indicators used in this study released at 100, 109, 119, 131, and 144 F. Three indicators were installed at each site, mounted on a wire rack with the wax bead as close to the soil surface as desired. Suspension in the 0- to 1-cm layer above the surface was chosen as adequate to show the temperature variation in the sites at each location.

Eleven locations (each with six measurement sites) were selected as typical of revegetation problem areas on the eastern Washington Cascade slope. These covered an altitudinal range of 3,000 to 6,000 ft and were all on southwest- to west-facing slopes. Soils at these locations were derived from sandstone or basalt parent material. Four locations were on sandstone and seven on basalt. Sandstone locations were at lower elevations (near 3,000 ft) than basalt (4,000 to 6,000 ft).

Cover on the measurement sites ranged from bare soil to a climax *Artemisia tridentata*/*Agropyron spicatum* association. Figure 1 is typical of a moderately productive sandstone location. Horizontal distance between the six sites at each location was about

20 ft for a total line length of about 100 ft. Locations were visited at approximately weekly intervals, maximum temperatures noted, and spent indicators replaced.

Results and Discussion

Although it was expected that the early summer samples would register moderate maximum temperatures (not greater than 119 F), this was soon found to be unrealistic. Temperatures early in the season exceeded 119 F, forcing the selection of the three indicators at each site to increasingly higher values. Unfortunately, with only three indicators at each site and the large observed variations, more measurements fell outside the available range than was desirable.

Figure 2 presents the data from all 66 measurement sites at the 11 locations. Locations are grouped according to basic soil material.

Limits of the indicators are shown for each location during each time period. An adjustment to higher limits was made during July. No attempt was made in Figure 2 to identify the six measurement sites at each of the locations. The figure indicates only whether the measurement sites at each location were within the limits of the indicators or the number of sites where measurements were either below or above the limits shown. Number of measurement sites outside of the limits are shown numerically either above or below the limit lines. The total number of measurement sites for each location is equal to six in any case.

Each of the 66 measurement sites could have been identified and its seasonal temperature regime examined if desired. Only one example of this site-to-site variation is shown (Fig. 1). This sandstone location had been contour trenched sometime in the past to aid in establishing vegetation and improving infiltration. Trenches are located in lower left and upper right of the photo. The role of the isolated arrowleaf balsamroot plant (*Balsamorhiza sagittata*) and the trough of the trench in reducing seasonal temperature extremes are seen. Figures show the maximum temperature known to be exceeded at (from lower left) the ridge of the trench, in partial live shade, beneath cured cheatgrass (*Bromus tectorum*), and in the trough of the trench. Differences of maximum

FIG. 2. Seasonal run of maximum temperature in 0-1-cm air layers on two soil types.

temperatures of at least 20 F over this short distance (about 10 ft) are seen.

At this location, on the basis of the seasonal march of temperature, some preferred locations for plant establishment can be identified. A similar assessment can be made for the typical sites at the other locations. Among the locations in the basalt grouping, the first plotted location in Figure 2 can be identified throughout the season as more moderate in maximum temperatures. This location was the highest in elevation and had the most dense cover (sagebrush).

In addition to the maximum at any site, onset and duration of excessively high temperatures are often equally important to plant survival. Short periods of exposure to high temperatures can often be tolerated, but prolonged exposure adversely affects most physiological processes (Meyer and Anderson, 1952). The site-to-site variation in this quite large sample allows only a very general statement about these features of the temperature regime. With the exception of the location shown in Figure 1 and the location with isolated sagebrush cover on the

basalt, large early-season variation appeared between the sites at any location and between sites on different locations. These differences became increasingly smaller with time. Sandstone sites at all locations, however, appeared to show more of this early variability and to reach higher absolute maximums earlier than comparable basalt sites.

Summary and Conclusions

With an easily used temperature indicator of limited resolution, we have been able to establish reasonable boundaries for the maximum temperatures developed near the surface on some of our problem areas. Large early season variability between sites, especially on the sandstone, more moderate extremes on the basalts, and longer periods of excess temperature on the sandstone were identified. Additional studies will be required to relate these temperature extremes to plant distribution and height, physical properties of the soils, seasonal moisture availability, and the energy balance of these semiarid lands.

Improvements in the indicator to increase range and resolution required for these future studies have been successful.

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